

Research note

Hot water, sodium carbonate, and sodium bicarbonate for the control of postharvest green and blue molds of clementine mandarins

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Abstract

Clementine mandarins cv. ‘Clemenules’, artificially inoculated with *Penicillium digitatum* or *Penicillium italicum*, were immersed in 0, 2, or 3% (w/v) sodium carbonate (SC) solutions at 20, 45 or 50 °C for 60 or 150 s. Decay incidence was determined after 7 days of storage at 20 °C and 90% relative humidity (RH). Hot water (HW) at 45 or 50 °C did not satisfactorily control both diseases. SC significantly enhanced decay control compared to water alone at all temperatures and for all immersion periods. Heated SC solutions were more effective than solutions at 20 °C. A 150 s dip in 3% SC at 50 °C totally controlled both green and blue molds without noticeably injuring the fruit. SC at 50 °C significantly reduced the incidence of both green and blue molds on mandarins stored at 3.5 °C for 60 days. Both diseases were reduced by 40–60% on mandarins dipped for 60 or 150 s in 2 or 3% sodium bicarbonate (SBC) solutions at room temperature. The effectiveness of all HW, SC, and SBC treatments on clementines was inferior to that obtained on oranges or lemons in related previous work. © 2002 Elsevier Science B.V. All rights reserved.

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1. Introduction

Clementine mandarin is the most economically important citrus crop in Catalonia (Spain). The most widely grown cultivar is ‘Clemenules’ (syn.: ‘Clementina de Nules’), which is primarily exported to European markets. Postharvest green

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mold, caused by *Penicillium digitatum* (Pers.:Fr.) Sacc., and postharvest blue mold, caused by *Penicillium italicum* Wehmer, are the most economically important postharvest diseases of clementines. Currently, both diseases are primarily controlled by application of synthetic fungicides. Alternative methods are needed because of concerns about environmental contamination and human health risks associated with fungicide residues and because the widespread use of these chemicals in commercial packinghouses has led to the proliferation of resistant strains of the pathogens.

Hot water (HW) treatments have been well studied for the control of postharvest decay of citrus fruits (Schirra et al., 2000). Treatments with sodium carbonate (SC, Na_2CO_3 , soda ash) and sodium bicarbonate (SBC, NaHCO_3 , baking soda) provided satisfactory control of green mold on lemons (Smilanick et al., 1995, 1999) and oranges (Smilanick et al., 1997, 1999; Palou et al., 1999) and blue mold on oranges (Palou et al., 2001). However, their efficacy against both diseases has not been evaluated on clementine mandarins. The aim of this work was to evaluate HW, SC, SBC, and combinations of HW and SC for the control of green and blue molds on artificially inoculated 'Clemenules' mandarins.

2. Materials and methods

Clementine mandarins (*Citrus reticulata* Blanco) cv. 'Clemenules', from commercial orchards in Tarragona (Catalonia, Spain), were inoculated in a 1 mm × 5 mm × 2 mm deep wound made on the equator of each fruit with 25 μl of a conidial suspension of 10^6 spores ml^{-1} of *P. digitatum* or *P. italicum*. About 2 h later, inoculated fruits were treated with HW, SC, or SBC in a 172-l stainless steel water tank fitted with a 9 kW electric resistance heater and thermostat as described by Palou et al. (2001). Three SC or SBC concentrations [0 (water alone), 2, and 3%, w/v] and two immersion periods (60 and 150 s) were tested. Water and SC solutions were tested at three temperatures [20 (control), 45, and 50, ± 1 °C]; SBC solutions were only tested at room

temperature (20 ± 1 °C) because heating the solution will cause carbon dioxide evolution into air with a concomitant increase in the pH of the solution (Smilanick et al., 1999). Each treatment was applied to four replicates of ten fruits each. Decay incidence was determined after 7 days of storage at 20 °C and 90% relative humidity (RH). Every test was conducted twice.

Additional tests with water alone at 20 or 45 ± 1 °C and 2% SC solutions at 50 ± 1 °C were performed to assess the efficacy of the treatments under long-term cold storage (60 days at 3.5 °C).

Decay incidence data were analyzed by analyses of variance of the arcsine of the square root of the proportion of decayed fruit using SAS software.

3. Results and discussion

HW dips at 45 or 50 °C for 60 or 150 s did not effectively control either green or blue mold. With decay incidence on the control treatments (water alone at 20 °C, SC concentration = 0) adjusted to 100%, the incidence of both green and blue molds on fruit treated with HW at 45 °C was greater than 75%, whereas at 50 °C it was about 50 and 70% for green mold and 65 and 80% for blue mold after 150- and 60-s dips, respectively (Fig. 1). Similar poor effectiveness for brief immersions

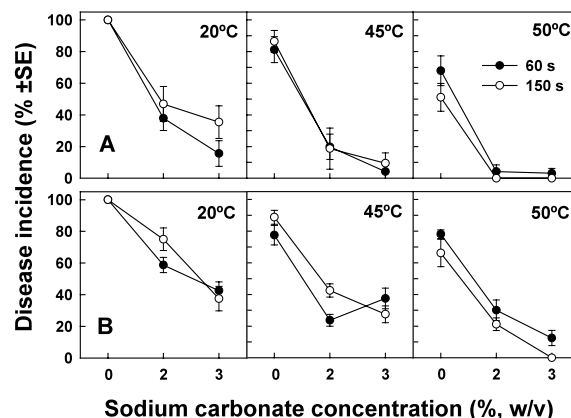


Fig. 1. Influence of solution temperature (20, 45, or 50 °C), sodium carbonate concentration (0, 2, or 3%), and immersion period (60 or 150 s) on the incidence of green (A) and blue (B) molds on artificially inoculated 'Clemenules' mandarins stored at 20 °C and 90% RH for 7 days.

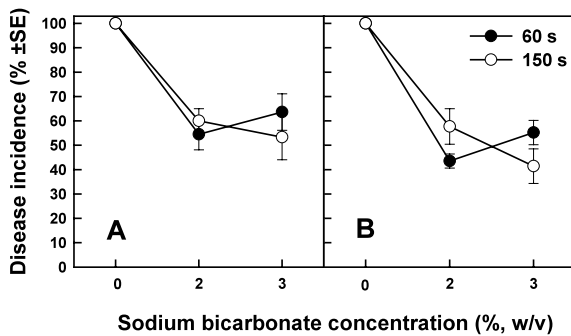


Fig. 2. Influence of sodium bicarbonate concentration (0, 2, or 3% w/v) and immersion period (60 or 150 s) on the incidence of green (A) and blue (B) molds on artificially inoculated 'Clemenules' mandarins treated at room temperature (20 ± 1 °C) and stored at 20 °C and 90% RH for 7 days.

in HW at 45 °C, but considerable better effectiveness for brief immersions in HW at 50–53 °C were reported against green mold of oranges (Palou et al., 1999), blue mold of oranges (Palou et al., 2001), or green mold of lemons (Smilanick et al., 1995).

SC treatment improved the control of both green and blue molds compared to the treatments with water alone (SC concentration = 0) at all temperatures and for all immersion periods. The incidence of green mold at concentrations of 2 or 3% SC was 5–20% at 45 °C and 0–5% at 50 °C. The incidence of blue mold was 20–40 and 0–30%, respectively (Fig. 1). No visible rind injury occurred in every test. Synergistic effects of heat and SC solutions to control *Penicillium* decay on citrus fruit were also observed in previous research (Smilanick et al., 1997, 1999; Palou et al., 1999, 2001). Hot SC solutions were more effective than HW at lower temperatures, which is important to minimize the risks of rind damage by heat. In the present work, a 150 s dip in 3% SC at 50 °C controlled totally both green and blue molds of mandarins without noticeably injuring the fruit. However, these temperature and SC concentration were higher than those needed to reach effective control on oranges with a dip of 150 s, namely 2% SC and 40–45 °C (Smilanick et al., 1997; Palou et al., 2001).

The incidence of both green and blue molds after 7 days of storage at 20 °C was 40–60% on mandarins dipped for 60 or 150 s in 2 or 3% SBC solutions at room temperature (Fig. 2). Similar treatments with SBC were more effective against both diseases on oranges or lemons (Smilanick et al., 1999; Palou et al., 1999, 2001).

On mandarins stored at 3.5 °C, the incidence of both green and blue molds after either 30 or 60 days of storage was significantly reduced by a pre-storage 150 s treatment with SC at 50 °C. SC at 50 °C was more effective than HW at 50 °C in controlling both diseases (data not shown). Control of blue mold was inferior to that of green mold, very likely because of the better adaptation of *P. italicum* to grow at temperatures below 10 °C. Similar results were obtained in artificially inoculated oranges stored at 3 °C for 60 days (Palou et al., 2001).

All HW, SC and SBC dips are non-curative treatments whose effects in vivo are primarily fungistatic and not very persistent. These effects cannot be predicted by their activity in vitro. The inhibitory ability of SC and SBC depends on the presence of salt residues within the wound infection courts occupied by the fungus and on interactions between this residue and constituents of the rind. These interactions presumably alter the original in vitro toxicity of the salts to the spores. Apparently, the particular interactions in the case of clementine mandarins compared to the interactions in the case of other citrus species such as oranges or lemons resulted, as shown by our results with 'Clemenules', in not so effective decay control.

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